the dorsal adjustor muscles are not attached to a hinge-plate, but are inserted into the valve itself. In *Rhynchonella psittacea* there is a pair of peduncular muscles. In *Lingula* there are six pairs of muscles, all of which have both extremities attached to the valves. They have been divided into adductors and sliding muscles, the latter again being subdivided into protractors and retractors; but the author, considering that no sliding motion takes place, regards the latter terms as improper, and gives a set of new names, of which a concordance with the older denominations is given on the preceding page.

The author conceives that the valves are separated by the action of the divaricators, combined with that of the parietals; these muscles compressing the visceral cavity posteriorly, and thus driving its contents into the anterior portion. The antagonists of these are the occlusors; while the office of the adjustors appears rather to be to supply the place of a hinge, and to prevent anything like sliding of the valves one over the other.

The muscular fibres of *Lingula* are smooth and unstriated. In *Waldheimia* those of the posterior occlusors are strongly striated, but the rest of the muscles have smooth fibres. The arms, their attachment and minute structure are next fully described.

In *Waldheimia* the canals of the attached portions of the arms coalesce into a single wide tube, which lies externally between the produced and reflected crura of the calcareous loop, and is separated by a partition from a canal of corresponding size—the "brachial sinus,"—which also extends throughout the whole length of the produced and reflected crura, and is in fact a prolongation of the perivisceral chamber. The cirri are arranged in this and all the other Brachiopoda examined, in a double alternating series—not in a single row, as has hitherto been stated to be the case. The walls of the brachial canal are tolerably well supplied with delicate muscular fibres, which run diagonally round the tube, and are most strongly developed towards the sides, near the grooved ridge which supports the cirri. An indistinct band of exceedingly delicate longitudinal fibres may also be observed nearly opposite to it. The author has however completely failed to discover, either here or in *Rhynchonella*, anything like the double spiral arrangements of fibres described by Prof. Owen, and believes that the latter observer has mistaken the blood-sinuses for muscles.

The author doubts whether the spiral coil can be unwound, and conceives that the muscular fibres described, are chiefly for the purpose of giving firm support to the grooved ridge on which the cirri and brachial fold are seated, and thus affording the complex muscular fibres which the ridge contains a better fulcrum whence to act upon the cirri.

In *Terebratulina caput-serpentis*, which possesses no calcareous loop, the pallial lobe connecting the produced and reflected portions of the arms is strengthened by calcareous spicula, which are so numerous as to preserve the shape of the part even when the animal basis is removed.

In *Lingula* the arms contain two canals; one, the anterior, being the equivalent of the single canal in *Rhynchonella*, and, like it, ter-

minating at the side of the œsophagus in a blind sac. The posterior brachial canal probably communicates with the perivisceral cavity and exhibits a peculiar arrangement of muscles, by whose action perhaps the arm can be exserted.

In addition to those parts of the alimentary canal and its appendages which are already known in the articulated Brachiopoda, the author describes a short median gastro-parietal band arising from the upper surface of the stomach and passing upwards and backwards to the dorsal parietes a little in advance of the hinge-plate. With regard to the existence or absence of an anal aperture in the articulated Brachiopoda, the writer states: "I have made numerous dissections under a powerful doublet, and have removed the part and examined it with a microscope: I have filled the tube with fluid as the fingers of a glove with air, and by pressure have attempted to force a passage: I have tried injections; but have equally, on all occasions, failed to discover an outlet, and have only succeeded in demonstrating more and more clearly the cæcal nature of the terminal extremity of the alimentary canal. Therefore, how much soever it may be opposed to analogy and to authority, the fact must be recorded—there is no anal orifice in *Waldheimia*, *Terebratulina*, or in *Rhynchonella*."

In *Lingula*, as in the articulated Brachiopoda, the first inflection of the intestine is towards the ventral surface, but the alimentary canal eventually ends in the easily observable anus placed nearer the dorsal than the ventral surface, on the right side of the body. The rudimentary mesentery, and the lateral gastro-parietal and ilio-parietal bands of *Lingula* are described. There is no median gastro-parietal band. Fæcal matter rolled into round pellets is commonly observable in the intestine of *Lingula*, while no fæces are ever found in that of the articulated Brachiopoda.

The genitalia in the articulate Brachiopoda are developed between the two membranes of which the inner wall of the pallial sinuses in which they are contained is composed, and, thrusting the inner of the two membranes from the outer, form a prominent mass connected by a band with the inferior wall of the sinus. The genital artery runs along the upper or outer edge of the band, and the genitalia are developed round it.

In *Lingula* the reproductive organs are withdrawn from the mantle and lodged within the visceral chamber, forming four irregularly lobulated or branched masses, two above and two below the alimentary canal, so that they may be distinguished as dorsal and ventral genital masses. The dorsal ovaries are suspended by the ilio-parietal bands, and the ventral by the continuation of these bands along the free margins of the pseudo-hearts. In both cases the attachment is along the margins of the bands, which are related to the genitalia much in the same manner as the suspending membrane is to the genital bands in *Waldheimia*; and it would seem that in *Lingula* the reproductive organs are really developed between the two layers composing the ilio-parietal bands. The author adduces arguments to show that the *Lingulæ* are hermaphrodite, the testis being a reddish mass, which ramifies over the true ovary.

The ova probably make their way out by the so-called "hearts," which open by their apices into the pallial cavity, and by their patulous bases (the so-called auricles) into the perivisceral chamber, and are hence capable of performing the functions of oviducts. The author has assured himself of the constant presence of the apical aperture of the pseudo-heart in all Brachiopoda. As pointed out by Prof. Huxley, there are four of these pseudo-hearts in *Rhynchonella*, but only two were found in the other Brachiopoda examined.

The pseudo-hearts have nothing to do with the propulsion of the blood, a function which is performed chiefly by the pyriform vesicle discovered by Prof. Huxley in *Waldheimia* and *Rhynchonella*, and which was found attached to the stomach in all the Brachiopoda examined. It is composed of two layers, the inner distinctly muscular, the outer transparent and homogeneous. Connected with this heart are vessels or blood-channels (particularly described in the Memoirs); the "venous canals," which open into it anteriorly, returning the blood conveyed by the posterior arterial channels into the system of peripheral sinuses originally described by Prof. Huxley.

Accessory "hearts" or pulsatile vesicles have been found in some of the articulated Brachiopoda; the mantle and the walls of the body are essentially composed of a plate of substance traversed by reticulated lacunæ, and lined upon each side with epithelium. After explaining at length the distribution of the lacunæ throughout the mantle, the sheath of the intestine, its bands, the genital folds, the arms, &c., the author proceeds to give the following sketch of the course of the circulation:—

"Having now gone over all that I have been able to ascertain with respect to the central and peripheral portions of the circulatory apparatus, and having also examined the lacunes and blood-canals of the brachial organs, it will not be difficult to follow the flow of the blood throughout its entire course in *Waldheimia*; and as it is in it, so will it be in all probability in all other Brachiopods.

"It has been shown that the heart is a simple, unilocular, pyriform vesicle, suspended from the dorsal aspect of the stomach, and projecting freely into the perivisceral chamber; that there is neither auricle nor pericardium,—unless the membrane which closely invests it can be so called,—that it is hardly more complex in structure than the pulsating vessel of the Tunicata; and that in *Lingula*, indeed, it scarcely at all differs from the heart of these lowly organized mollusks. This vesicle, or heart, propels the blood through four arterial trunks or channels, to the reproductive organs and mantle, and probably also to the alimentary tube, and is apparently assisted by four or more pulsating vesicles in connexion with these principal trunks. The blood thus conveyed by the genital or pallial arteries will escape by the lacunes in the membranes suspending the genitalia, into the plexus in the floor of the great pallial sinuses. Thence it will find its way into the outer lacunary system of the pallial lobes, and into that of the dorsal and ventral walls of the body, as well as into the lacunes of the anterior parietes. Having saturated all these parts of the peripheral system, it will divide itself into two currents, one of

which will set backwards in the direction of the membranous bands connecting the alimentary tube to the parietes, and will flow through their channels into the system of visceral lacunes, which encircle the alimentary canal within the sheath, and which probably carry blood to the liver. This current will also supply blood to the lacunes nourishing the muscles. The blood thus directed will reach the branchio-systemic vein, either by the great œsophageal lacunes, or through the foramina which penetrate the sides of the channel as it runs along the dorsal ridge of the stomach.

"The other blood-current will set forward in the direction of the base of the arms, and some of it will pass into these organs through their general system of lacunes; but the principal portion will be carried by the afferent brachial canal to the extensive plexus of lacunes in those parts, and will circulate, in the manner before pointed out, within the walls of the great brachial canal. The blood will then be drawn up one side of the cirri through the vessels—the afferent brachial arteries—originating in the great brachial plexus, and returning down the other, will be poured into the efferent brachial canal, and thus reach the lateral efferent sinuses at the root of the œsophagus. Thence it will enter the great œsophageal lacunes, and there meeting with the other current of returning blood from the visceral lacunes, will be carried to the heart by the branchio-systemic vein along the dorsal side of the stomach.

"Thus it is perceived that the blood finds its way back to the central organ in a mixed condition. That which is conveyed by the gastro-parietal and other bands will be imperfectly aërated, having only flowed through the pallial membranes, which must be looked upon as but accessory oxygenating agents. The arms undoubtedly perform the office of gills, and are true respiratory organs. The blood which circulates through them will consequently be returned in a perfectly aërated condition, to be mixed, however, with that in a less pure state from the visceral lacunes before it enters the heart. This mixed state of the blood is not by any means peculiar to these animals, for it obtains in many of even the higher mollusks."

The perivisceral cavity and the great pallial sinuses have no communication with the proper blood-vascular system, but are to be compared to the atrium of the Ascidianida, and the water-chambers of the Cephalopoda and other mollusca. The pseudo-hearts enable the perivisceral cavity to communicate with the exterior, and convey away the genital, and probably the renal products. On this head the author says:—

"From the foregoing account of the circulatory apparatus, it would appear that the perivisceral chamber, and its various so-called vascular ramifications in the mantle, are not connected with the blood-system. This is no doubt a startling fact. I commenced the present investigation fully imbued with the opinion that these parts were blood reservoirs and channels, and I only relinquished it when it became no longer tenable. Step by step the points relied on had to be abandoned, until at length the full conviction was arrived at that I had been seeking to establish a fallacy. I have been unable